Improvement of Product-life and Chipping-resistance of a Cemented Carbide Rotary Cutter by Cemented Carbide-coated (CC) Anvil Roll

超硬コーティングアンビルロール（CC アンビルロール）適用による超硬ロータリーカッターの寿命および耐チッピング性の向上

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キーワード；NT ダイカッター , ロータリーカッター，アンビルロール , 長寿命，耐摩耗性，刃先チッピング , 高信頼性

Abstract

The NT Die Cutter consists of a die cutter having three dimensional cutter blades on the cylindrical outer surface and an anvil roll having a smooth cylindrical outer surface. NT Die Cutter is used all over the world as a cemented carbide rotary cutter for processing the outline of sanitary napkins and diapers at high speed. We developed “CC Anvil Roll”, an anvil roll which satisfies both a long operational lifetime and low risk of cutting edge chipping（Patent No. 5797408）. CC Anvil Roll (Cemented Carbide-coated Anvil Roll) has a thin hard layer and achieves a long operational lifetime due to the excellent wear resistance of it and reduces the risk of cutting edge chipping with its cushion performance making use of low Young's modulus of the base material. In this study, we conducted a running test with other materials and carried out a comparative evaluation of CC Anvil Roll based on its abrasion behaviors. As a result, it was confirmed that CC Anvil Roll has excellent wear resistance comparable to a cemented carbide anvil roll and reduces the risk of cutting edge chipping.

NT ダイカッターは外周上に刃先を形成するダイカッターと外周が平坦なアンビルロールからなり、ナプキンやおむつなどの高速輪郭加工用超硬合金製ロータリーカッターとして､Global 市場で広く使用されている。ダイカッターの長寿命化と刃先損傷のリスク低減を両立させるアンビルロールとして「CC アンビルロール」を開発した（特許 5797408）。CC アンビルロール（超硬コーティングアンビルロール）はロール表面に WC-Co の薄い硬質層を有しており、それによる耐摩耗性と母材の低ヤング率を生かしたクッション性能で長寿命化と刃先損傷のリスク低減を実現する。本研究では他の材料とともに実機稼働試験を行い、その摩耗挙動から CC アンビルロールの効果を比較評価した。その結果、CC アンビルロールは超硬合金製アンビルロールに匹敵する優れた耐摩耗性を有しており、刃先チッピングのリスク低減効果も確認された。

1.Introduction

In 1986, NT Die Cutter was commercialized as a cemented carbide rotary cutter for processing the outline of paper and non-woven cloth which were difficult to be cut by mold. NT Die Cutter consists of a rotary cutter having three dimensional cutter blades on the cylindrical outer surface and an anvil roll having a smooth cylindrical outer surface. NT Die Cutter cuts a raw material sheet to the product shape as required by passing it between those two rolls. Nippon Tungsten has provided cemented carbide rotary cutters combined with anvil rolls consisting of ferrous materials such as cemented carbides and dies steels. The combination of a cemented carbide rotary cutter with a cemented carbide anvil roll can achieve a long operational lifetime due to the excellent wear resistance of cemented carbide while excessive force is applied to the cutting edge due to exterior environment factors such as temperature and vibration and the risk of cutting edge chipping becomes relatively higher. With respect to the combination of a cemented carbide rotary cutter with a steel anvil roll, the risk of cutting edge chipping is low but the operational lifetime is shorter than that of the combination of a cemented carbide rotary cutter with a cemented carbide anvil roll. We developed “CC Anvil Roll”, an anvil roll which satisfies both a long operational lifetime and low risk of cutting edge chipping. CC Anvil Roll has a thin hard layer of WC-Co on the cylindrical outer surface and achieves a long operational lifetime due to the excellent wear resistance of it and reduces the risk of cutting edge chipping with its cushion performance making use of low Young's modulus of the base material.

2.Experimental

We conducted a running test for CC Anvil Roll combined with a cemented carbide rotary cutter in order to confirm the performances of it. The following two items were evaluated as compared to other materials:

1) Wear resistance; and
2) Effect of CC Anvil Roll on the cutting edge.

In the running test, we used a cemented carbide rotary cutter and a test anvil roll shown in Fig.1. Since the test anvil roll consists of CC Anvil Roll and a cemented carbide anvil roll and a steel (JIS SKD11) anvil roll, a relative evaluation is possible during the simultaneous test. Table 1 shows the hardness of the cemented carbide rotary cutter and each anvil roll. In order to measure the hardness of cemented carbide and steel (JIS SKD11) and CC Anvil Roll, we used HV30 and HV0.3 Vickers hardness tests, respectively. It is impossible to measure the hardness of thin hard layer on CC Anvil Roll’s surface using a HV30 Vickers hardness test because of low Young's modulus of the base material.

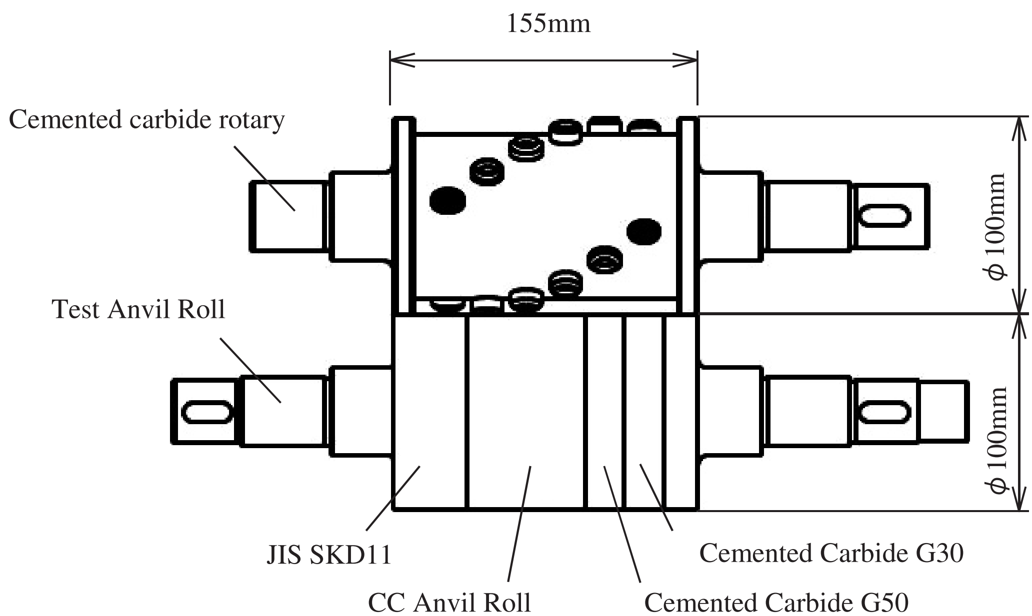


Fig.1 Schematic of a performance evaluation test for CC Anvil Roll

Table 1. Hardness of cemented carbide rotary cutters and CC Anvil Roll

Material Grade	Vickers hardness
Carbide Die Cutter FND30	1633
CC Anvil Roll	1167
JIS SKD11	685
Cemented Carbide G50	1071
Cemented Carbide G30	1199

In this test, cemented carbide die cutters and anvil rolls were operated under the conditions close to the actual ones, i.e. running test conditions shown in Table 2, and their cutting edges were worn. The load to rolls increased from 490 kgf at the beginning of the test up to 1,490 kgf by 245 kgf per 50,000 rotations.

During the running test, abrasion flaws are generated on the anvil roll surface due to the contact with the cutting edge. We measured the depth of those flaws on the anvil roll surface and investigated the abrasion behavior of CC Anvil Roll comparing with other materials. The depth of abrasion flaws was measured by a surface roughness measuring device.

The blade height of a die cutter is lowered as the abrasion of the cutting edge progresses. Further, the cutting edge is rounded and the land width of the edge top increases. The larger the load to the cutting edge, the more the edge height is lowered and the larger the land width becomes. By measuring the decrement of blade height and the increment of edge land width, we evaluated the effect of CC Anvil Roll on the cutting edge. The decrement blade height and the increment of edge land width were measured by a dial gauge and a microscope, respectively.

Table 2. Conditions of the running test

Item	Conditions
Rotational speed	600rpm
Total number of rotations	250,000
Load on the Roll	490-1469kgf
Driving method for Anvil Roll	Receiving a driving force of the motor through a pulley
Driving method for Die Cutter	Receiving a driving force by the fiction force between die cutter and anvil roll

3.Results and Discussion

3-1 Wear resistance of CC Anvil Roll

With regard to the depth of abrasion flaws on the anvil roll surface generated by the contact of the cutting edge, a comparative chart according to the anvil roll material is shown in Fig.2. The descending order of the depth of abrasion flaws is as follows: steel (JIS SKD11), Cemented Carbide G50, CC Anvil Roll and Cemented Carbide G30. This result indicates that CC Anvil Roll has excellent wear resistance equivalent to that of the cemented carbide anvil roll.

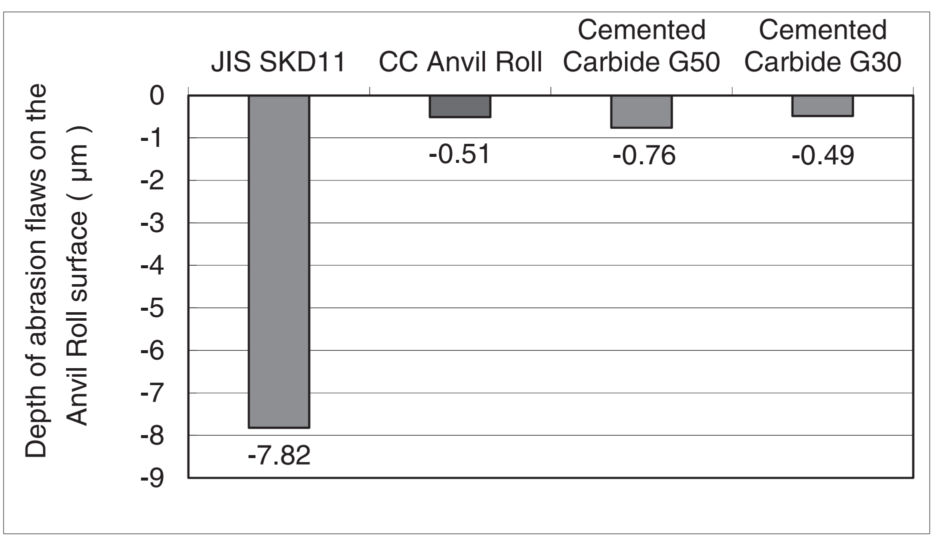


Fig. 2. Comparison of depth of abrasion flaws on each Anvil Roll

3-2 Effect of CC Anvil Roll on the cutting edge

With regard to the decrement of blade height after the running test, a comparative chart according to the anvil roll material is shown in Fig.3. The ascending order of the blade height is as follows: Cemented Carbide G30, Cemented Carbide G50, CC Anvil Roll and steel (JIS SKD11). This result indicates that CC Anvil Roll applies a less load on the cutting age than the cemented carbide anvil roll.

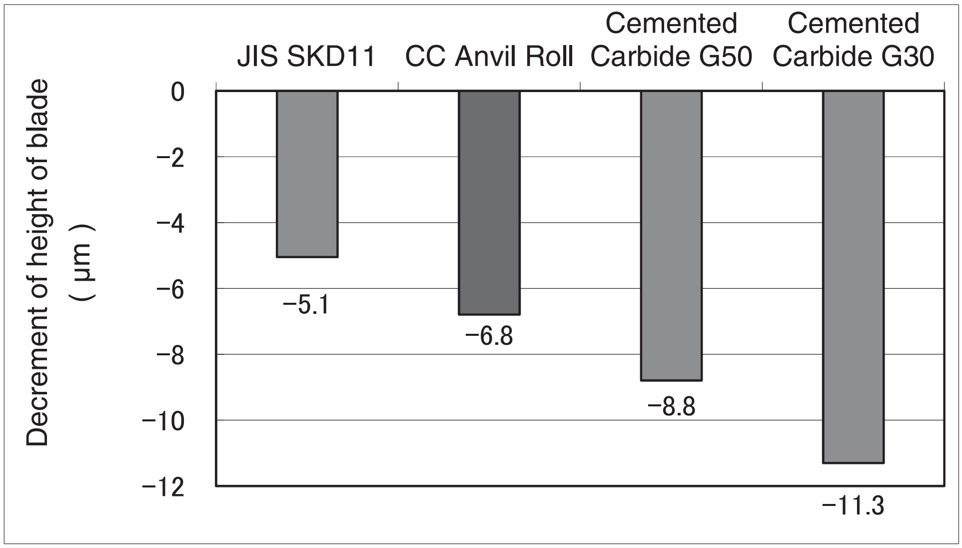


Fig.3 Comparison of the decrement of blade height according to the anvil roll

As for the increment of the edge land width associated with the increase in the load on the roll, a comparative chart according to the anvil roll material is shown in Fig.4. The edge land width was measured by a digital microscope after operating 50,000 rotations under the each load condition. The increment of the land width of the die cutter which contacted Cemented Carbide G30 is the largest. Focusing on the tendency of increasing the edge land width, we found that the land width of the cutting edge which contacted CC Anvil Roll increases more slowly than the cemented carbide anvil roll as the load increases. On the other hand, the land width of cutting edge which contacted Cemented Carbide G30/G50 rapidly increases at an early stage of the running test. After that, the land width increases slowly.

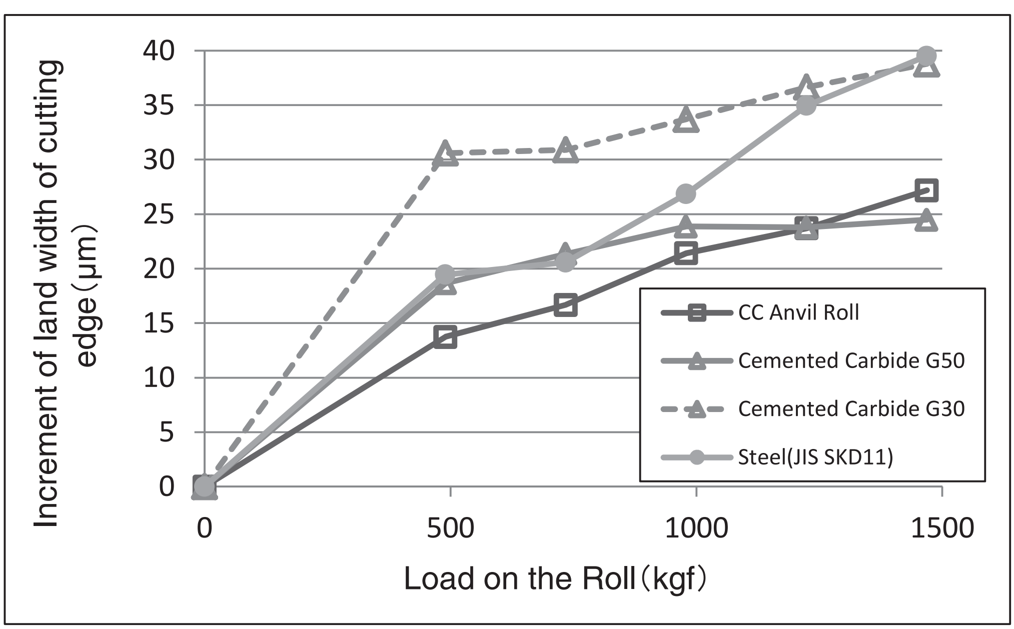


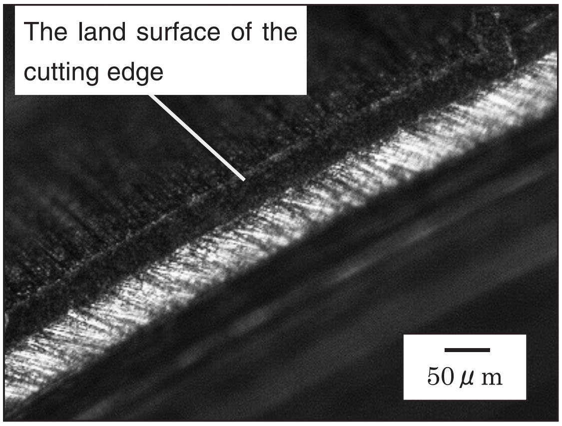
Fig.4 Comparison of the increment of the land width according to the anvil roll

With respect to the cutting edge which contacted CC Anvil Roll or Cemented carbide G30, photos of cutting edges in an early stage of the running test are shown in Fig.5. There are many chippings on the cutting edge which contacted Cemented Carbide G30 and the land width increases by them. On the other hand, there are fewer chippings on the cutting edge which contacted CC Anvil Roll. It can be guessed that the rapid increase in the land width at an early stage of the running test shown in Fig. 4 is caused by the unusual wear due to chippings. Based on the comparison of increase in the land width in Fig. 4, it seems the cutting edge is rapidly worn by chippings in the area where the land width rapidly increases and chippings are suppressed and the cutting edge is slowly worn in the area where the land width slowly increases.

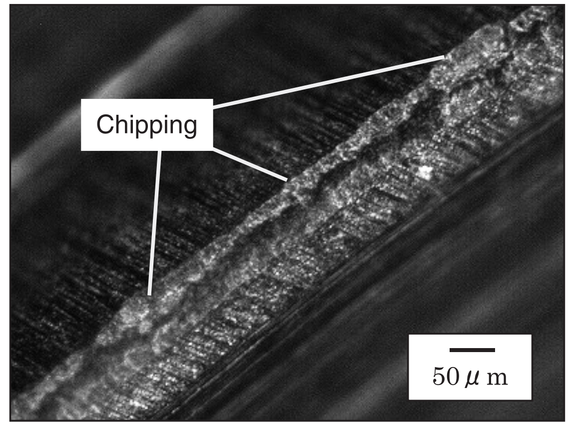
Comparing the increment of the land width between cutting edges contacting G30 and G50, the land width of the cutting edge which contacted G30 more increases. This result seems to be caused by the hardness difference of the materials, i.e. the cutting edge which contacted a harder anvil roll was worn significantly. On the other hand, although there is no clear harness difference between CC Anvil Roll and Cemented Carbide G30, the increment of the land width of the edge which contacted CC Anvil Roll is clearly less than that with Cemented Carbide G30. It is guessed that Young's modulus of anvil roll has a significant impact on these results.

CC Anvil Roll consists of a base metal with low Young's modulus coated with a thin hard layer. Young's modulus of entire CC Anvil Roll seems to be lower than that of the cemented carbide anvil roll. Guessingly, CC Anvil Roll suppresses the occurrence of excessive stress to the cutting edge due to the difference of elastic deformation volume of the anvil roll when contacting the cutting edge.

From the running test, it was found that since there are fewer chippings on the cutting edge which contacted CC Anvil Roll at an early stage and there is no rapid increase in the edge land width caused by chippings on the edge, it can be said that the use of CC Anvil Roll has an effect on the reduction of cutting edge’s damage risk.

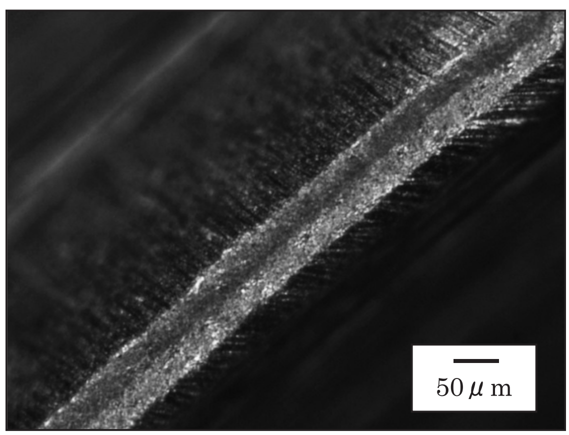


(a)



(b)

Fig.5 Photos of cutting edges after 50,000 rotations under a load of 490kgf on the roll
(a) Cutting edge which contacted CC Anvil Roll
(b) Cutting edge which contacted Cemented Carbide G30 anvil roll



(a)

Fig.6 Photo of a cutting edge after 50,000 rotations under a load of 1469kgf on the roll
(c) Cutting edge which was contacted with steel (JIS SKD11) anvil roll

The land width of the cutting edge which contacted the dies steel anvil roll increases as same as that which contacted Cemented Carbide G30 anvil roll. The photo of the cutting edge which contacted steel (JIS SKD11) anvil roll is shown in Fig.6. This photo was taken after the cutter rotated 50,000 times under a load of 1469kgf on the roll. The shape of the land surface on the cutting edge which contacted steel (JIS SKD11) anvil roll is different from other cutting edge shapes. After the running test, the depth of abrasion flaws on the steel anvil roll is about 10 times deeper than those on other anvil rolls. That affects the difference of the cutting edge shape.

4.Conclusions

We developed "CC Anvil Roll", as a means which satisfies both a long operational lifetime and low risk of cutting edge chipping (Patent No. 5797408) and evaluated it with a running test. The results are described below:

(1) CC Anvil Roll has excellent wear resistance comparable to a cemented carbide anvil roll.
(2) There are fewer chippings on the cutting edge as compared to a cemented carbide anvil roll.
(3) The use of CC Anvil Roll is effective in satisfying both a long operational lifetime of a die cutter and reduction of cutting edge's damage risk. It is guessed that this is caused by CC Anvil Roll's high hardness and low Young's modulus.

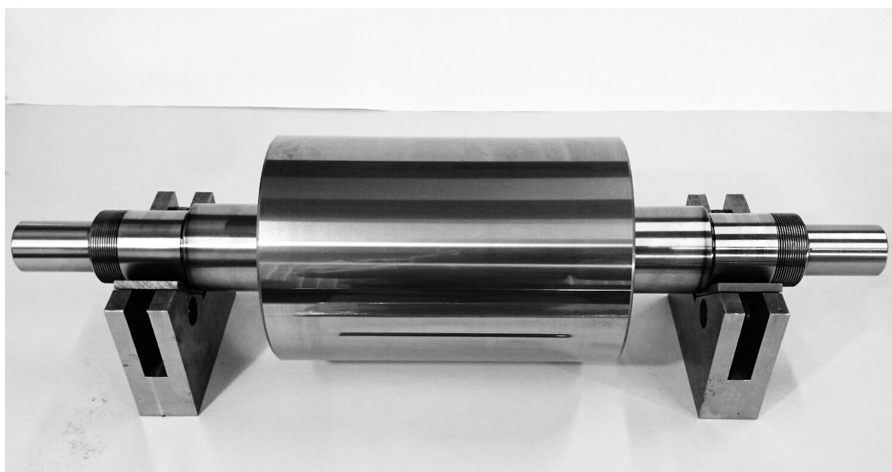


Fig.7 The appearance of CC Anvil Roll